Site characterization of fluvial, incised valley deposits

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CO_2 budget for my trip

- Copenhagen-London r. 342 kg
- London-S.F. r. 2,132 kg
- rental car 56 kg

- Total emission caused by my symposium participation

2.5 tons

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Fluvial sequence as CO_2 reservoir - and what we worry about:

- Facies pattern & reservoir properties
  - Volume
  - Injectivity
  - Vertical connectivity
  - Horizontal connectivity
  - Migration path length from injection point

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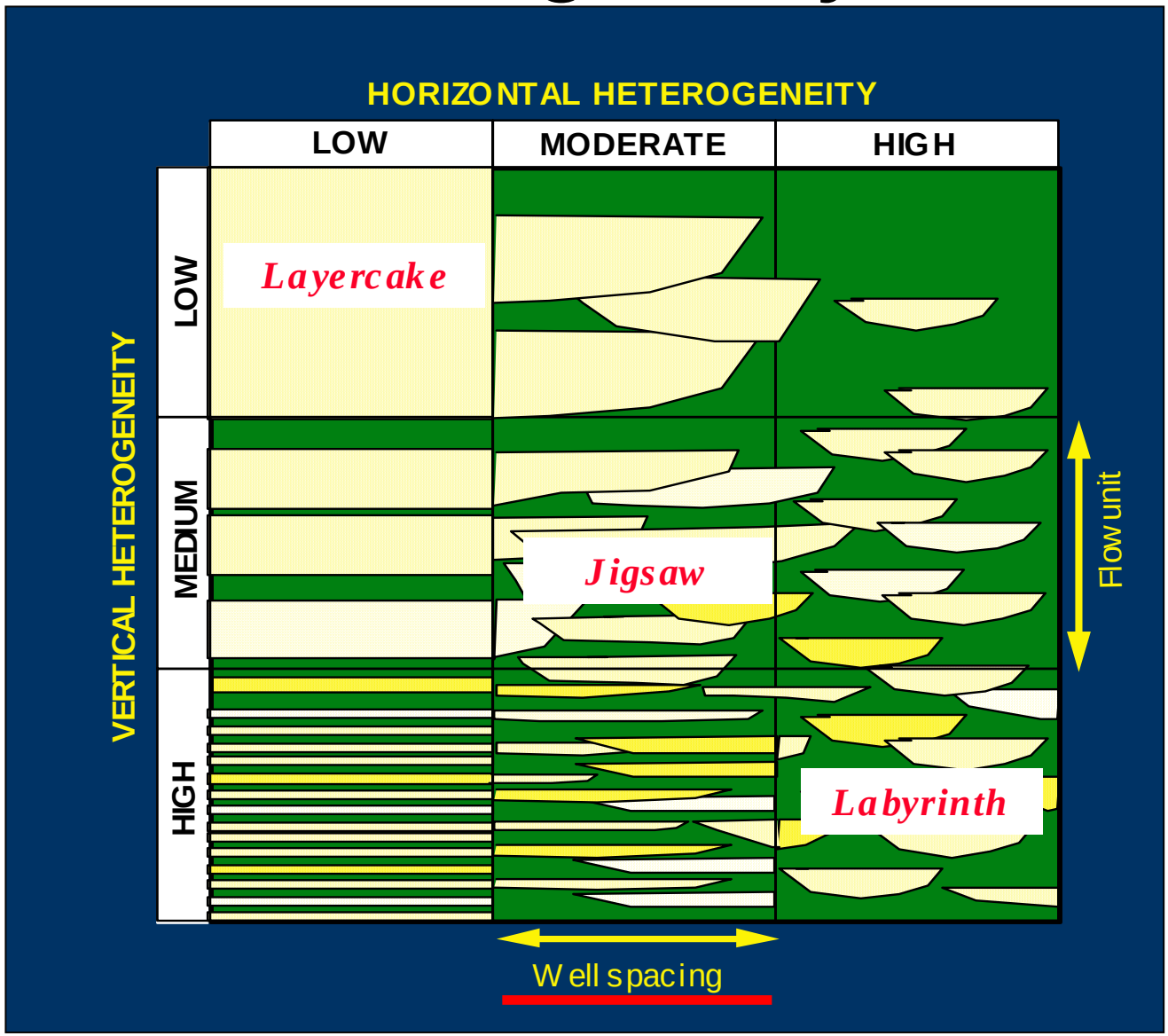
Heterogeneity



(Tyler & Finley, 1991)

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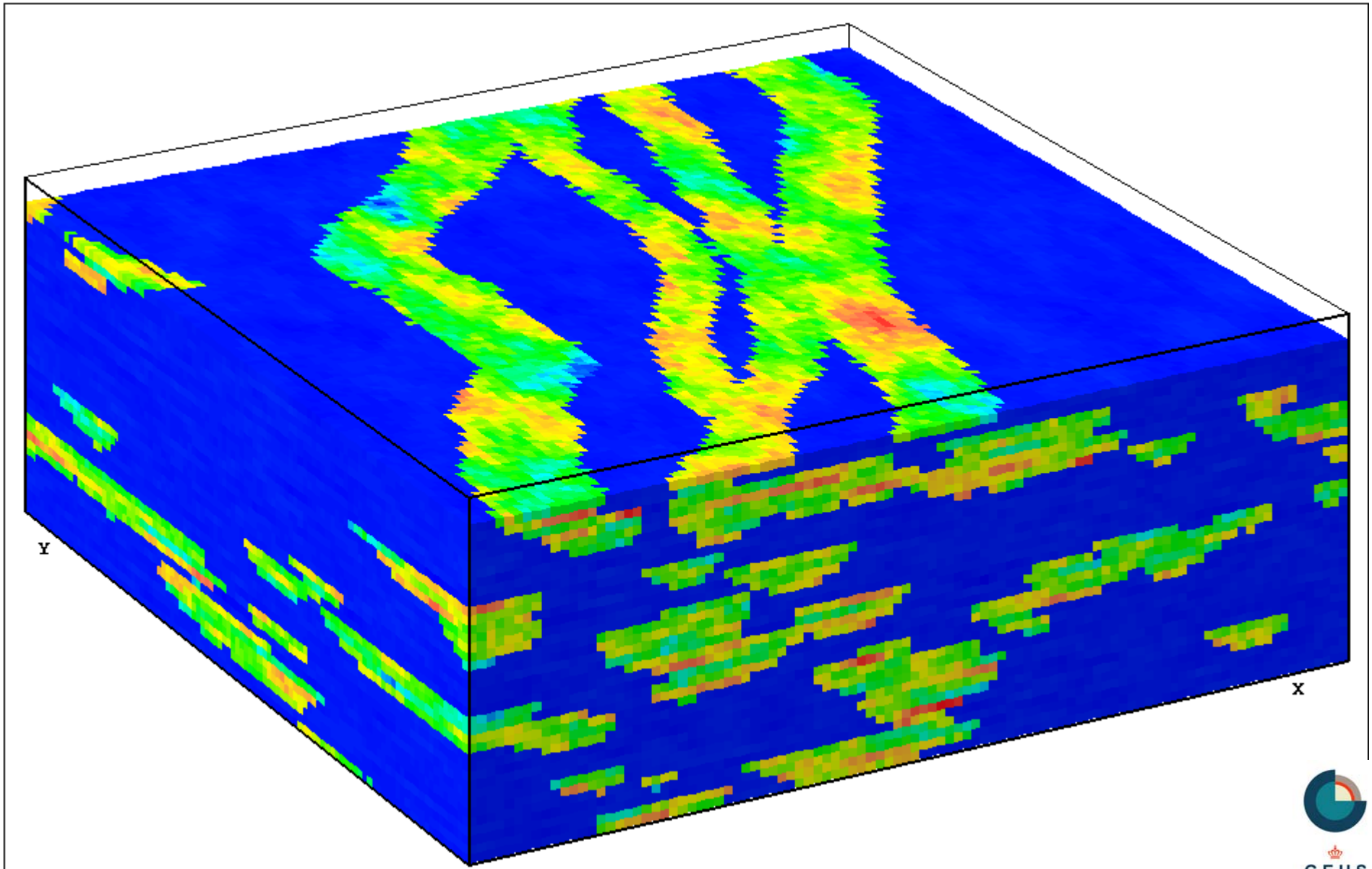
Model 10x10 km, 80 m thick



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Case: The Ketzin storage site

- The site is located at Ketzin some 25 km west of Berlin, Germany.
- Demonstration project with injection and monitoring.
- Supported by EU 6th Framework Pogramme
- It is planned to inject approximately 60,000 tons of CO_2 into the saline aquifer over 2.5 years, starting 2007?
- The target reservoir lies between 600 and 700m depth - i.e. not supercritical conditions

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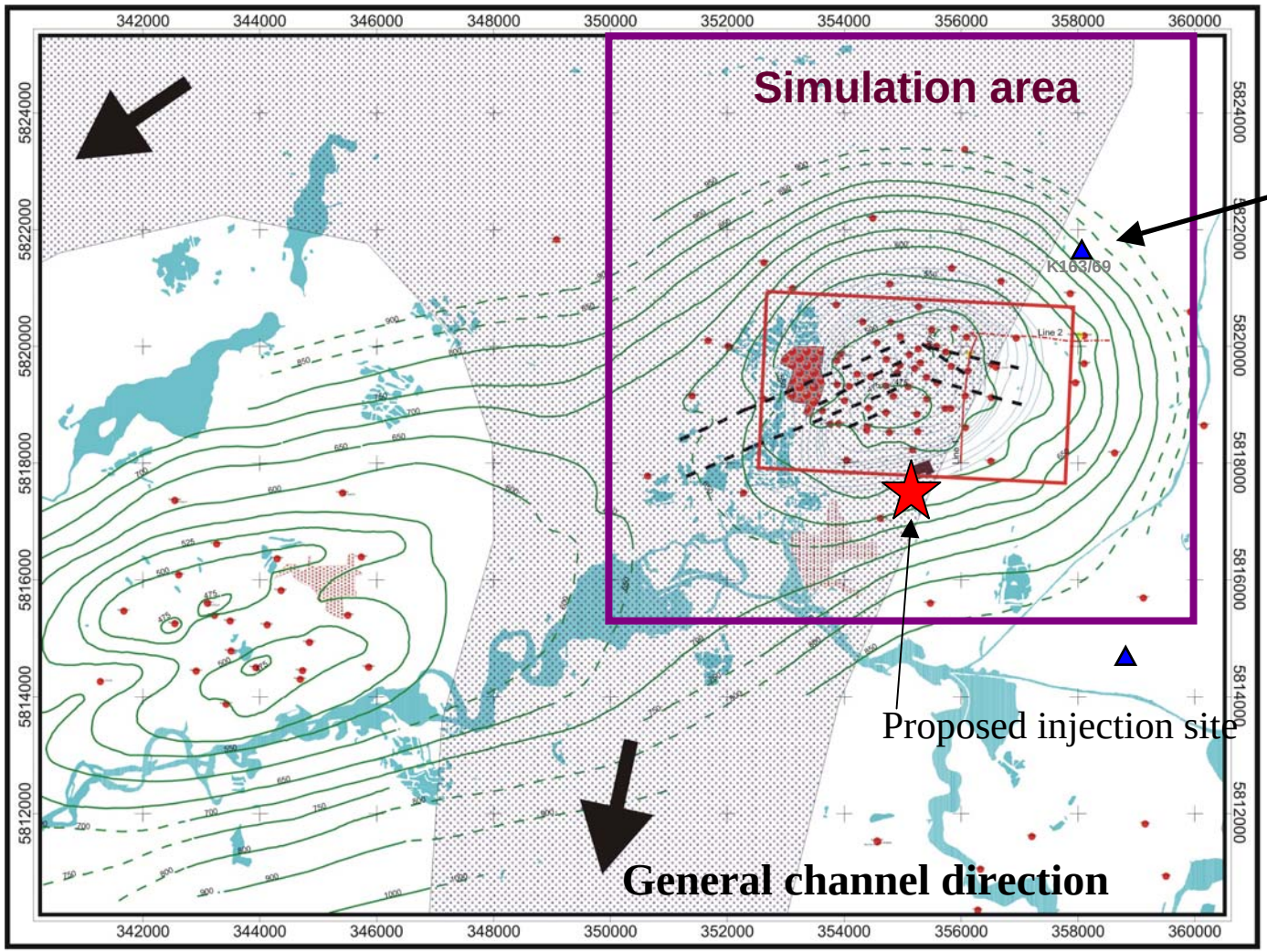
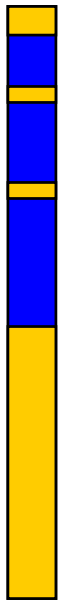
Area of interest 10x10 km
on domal structure, with data from single well



Well
K163/69



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Geological model and input

- Incised valley with floodplain and channel belt facies
- Channel belts, not the individual river channel, used as objects in model
- Net/Gross areal variation estimated from paleo-geography
- Channel belt parameters: width/thickness and tortuosity, deduced from analog studies and published models
- A single well in area available

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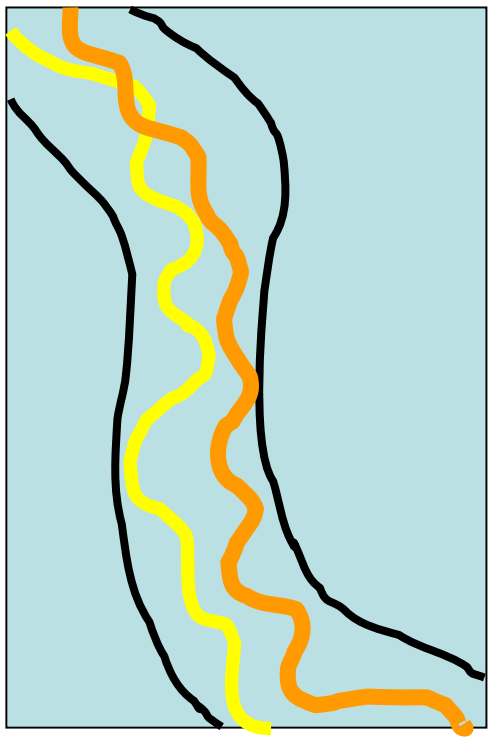
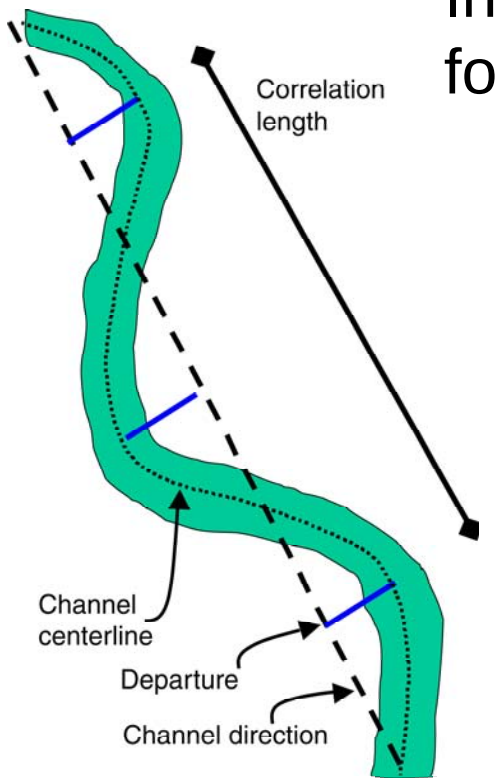
FLUVSIM

- Object modelling using simulated annealing (Deutsch & Tran, 2002)

Channel belt



Input parameters for geometry



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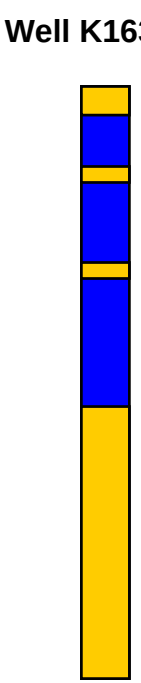
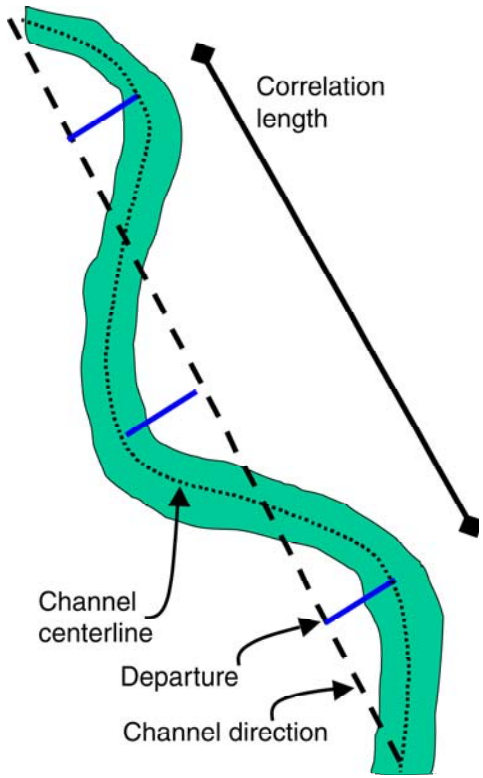
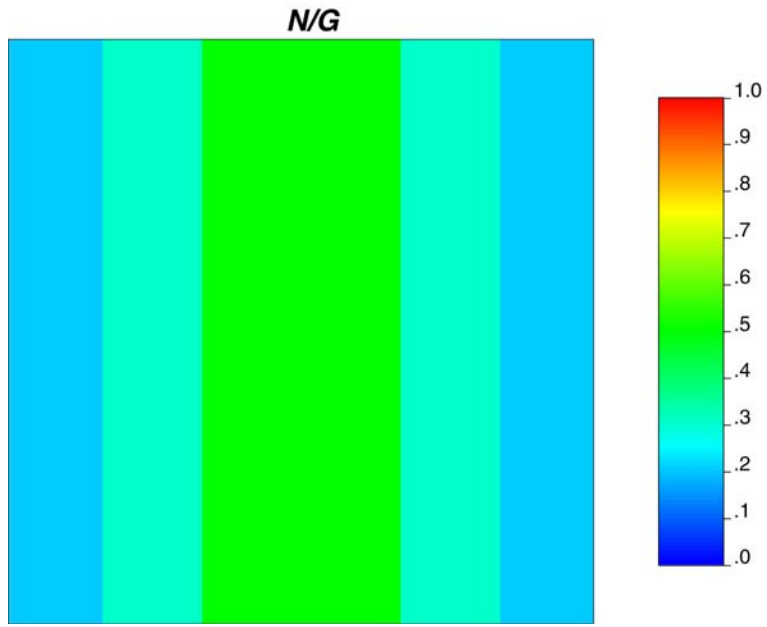
Input for FLUVSIM

Well data Channel param. Proportion N/G map avg.= 33%







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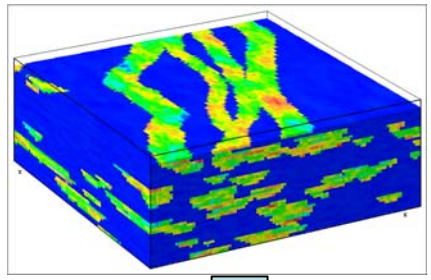
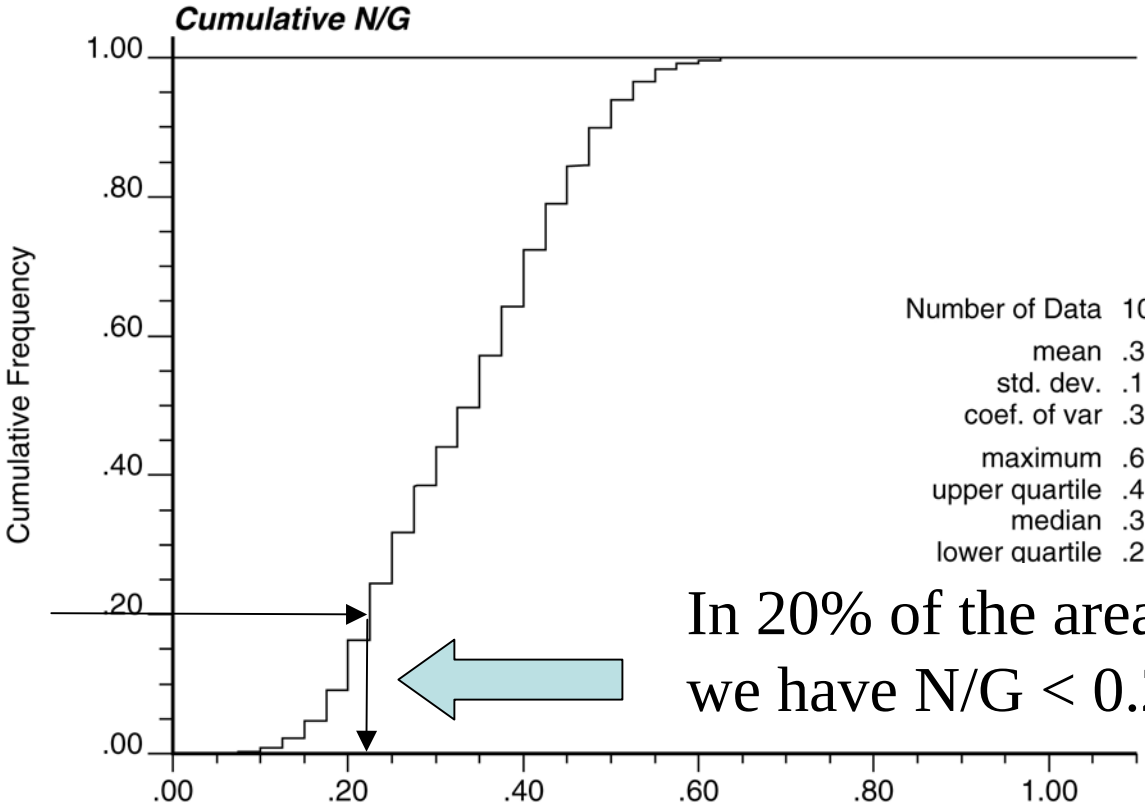
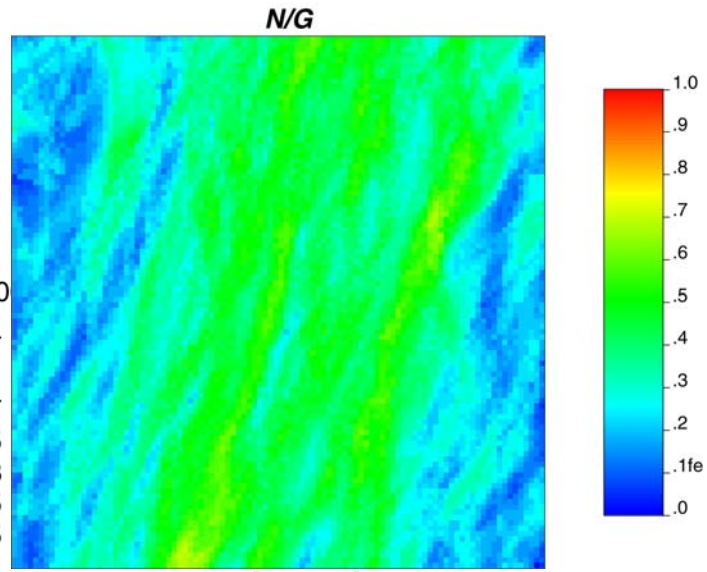
N/G distribution





In 20% of the area we have N/G < 0.23



Realisation 1

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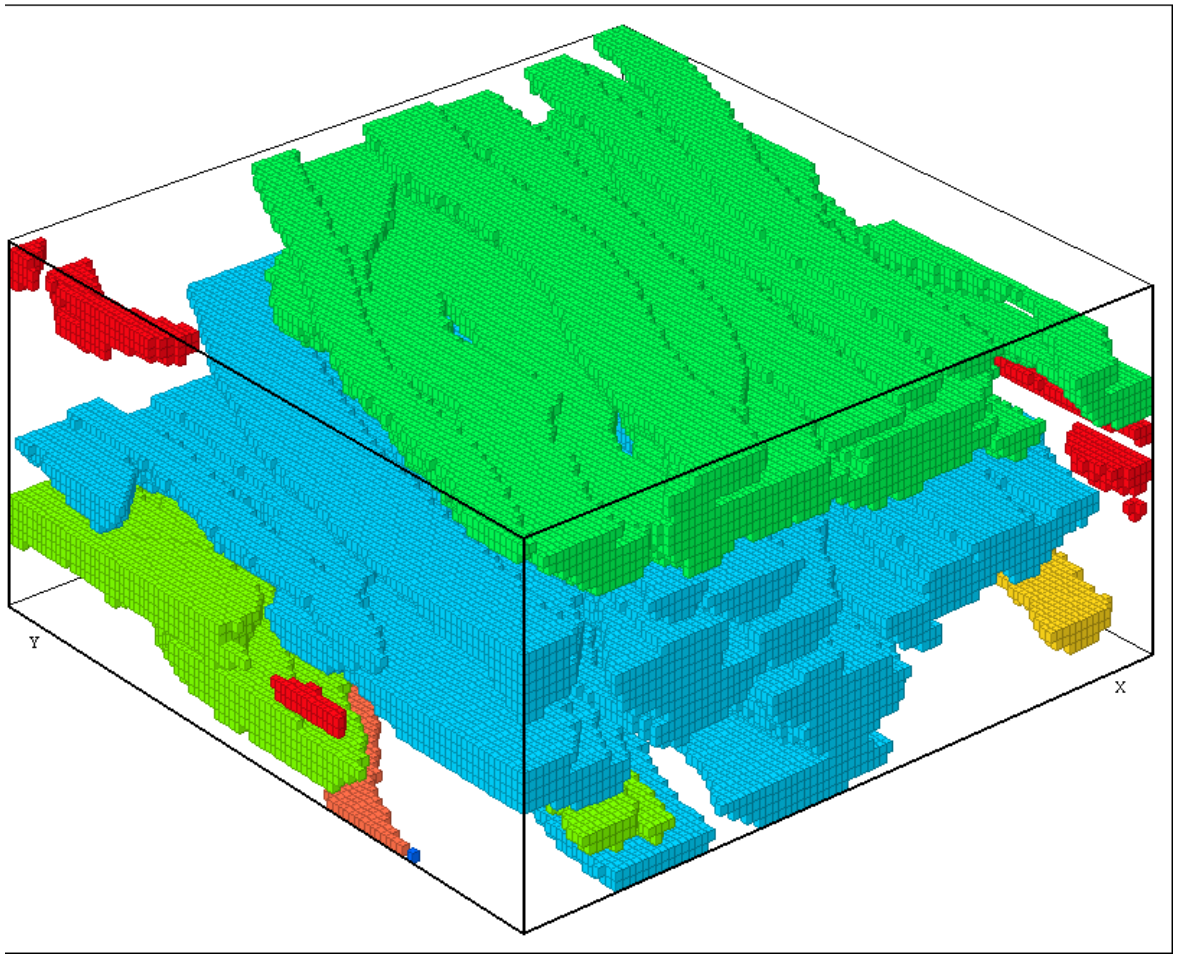
Vertical connectivity?

Shown by color-coding connected sand-bodies



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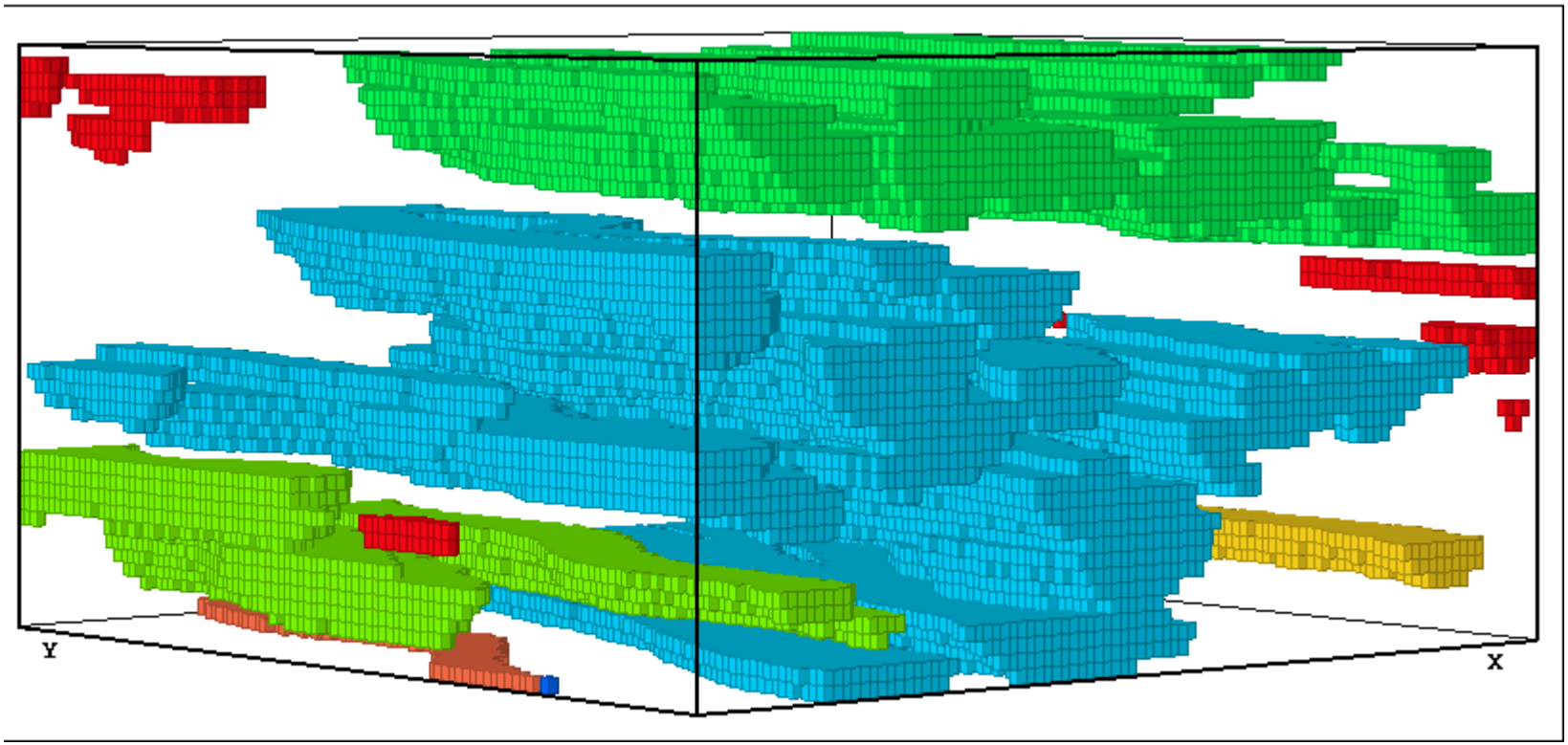
Clear separation between sands



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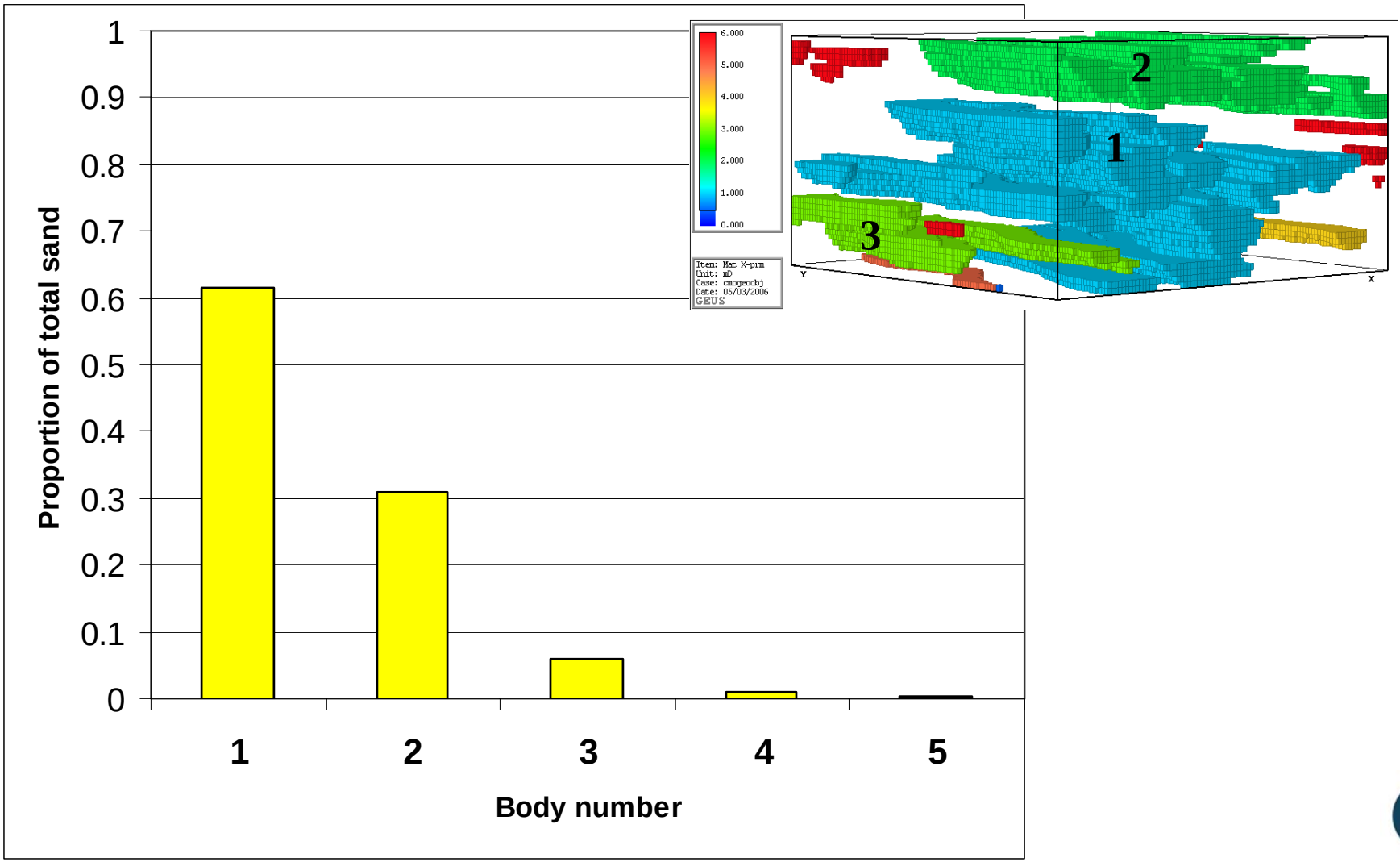
Volume proportions of sand bodies compared to total sand volume



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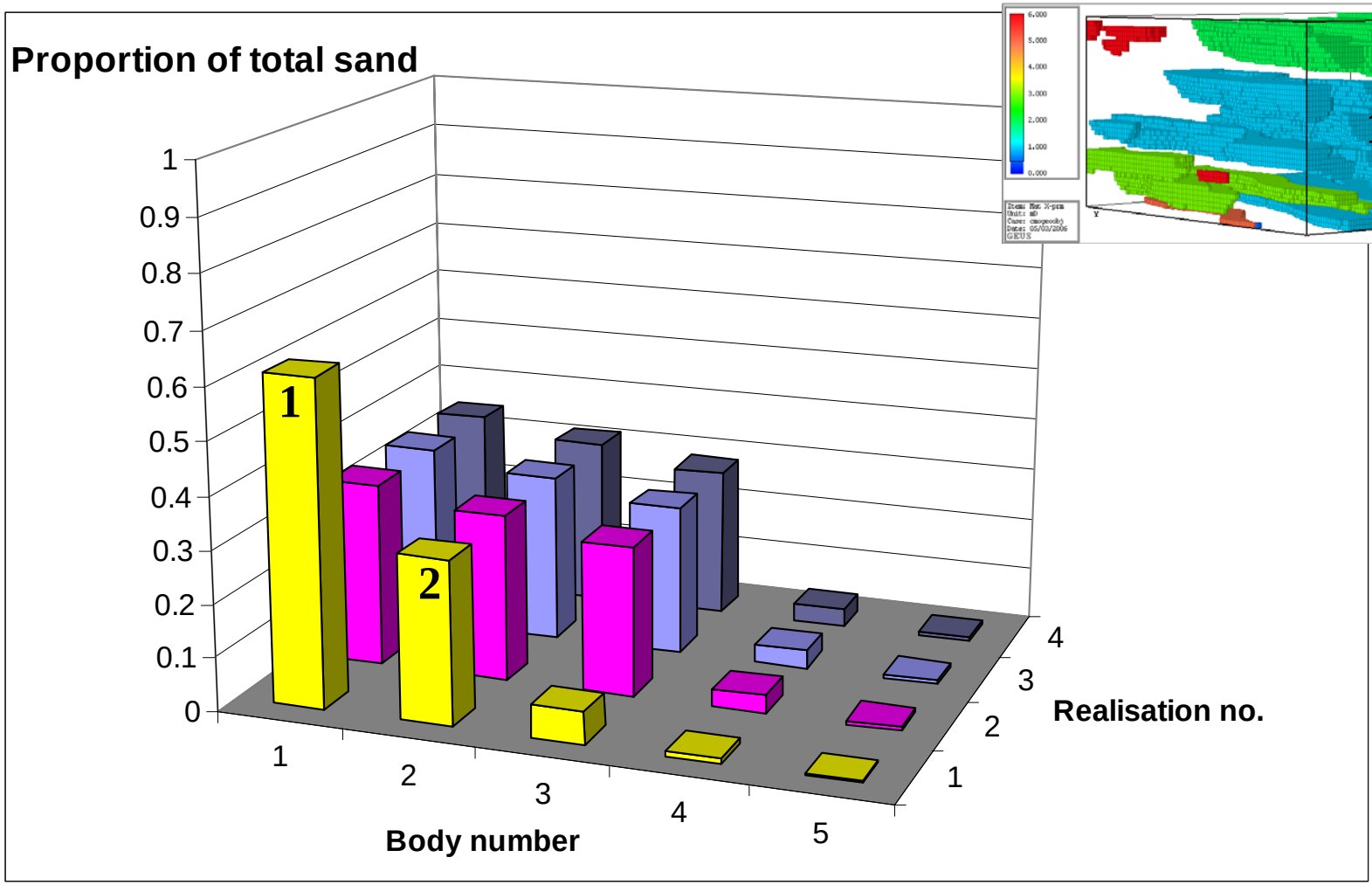
Sand-body connectivity varies in 4 realisations



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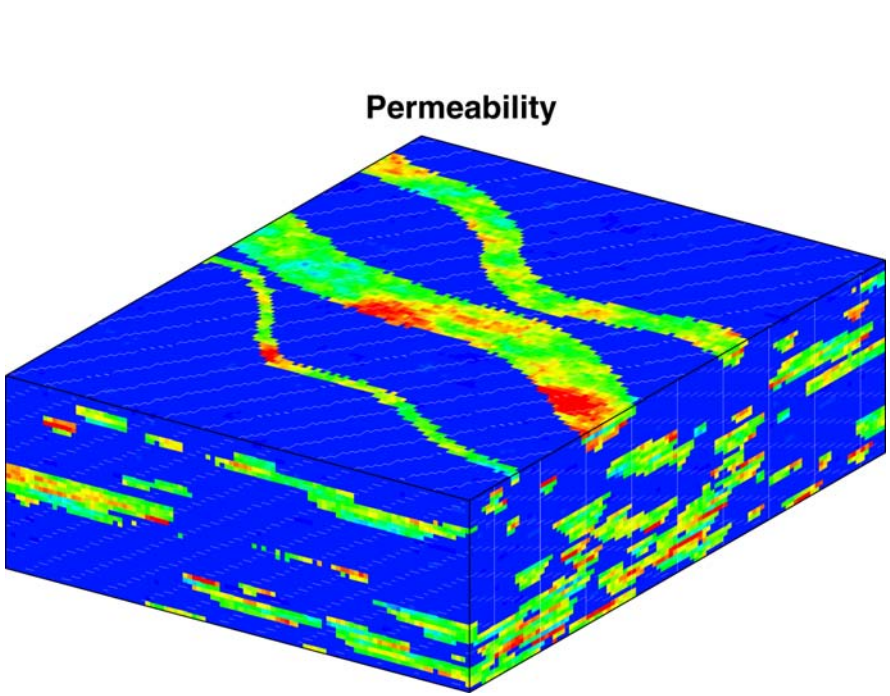
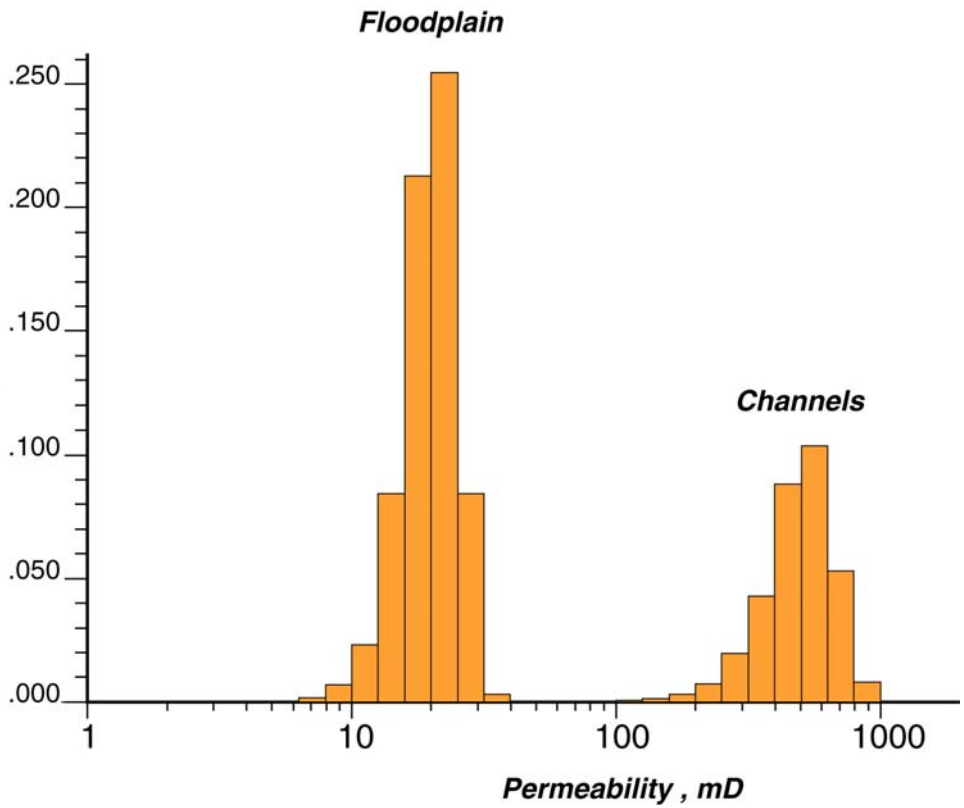
Permeability model

- Created by merging facies with permeability simulation with correlation structure





Are we finished?

√ Data

√ Characterisation

√ Modelling

√ Flow properties

- Upscaling issues?

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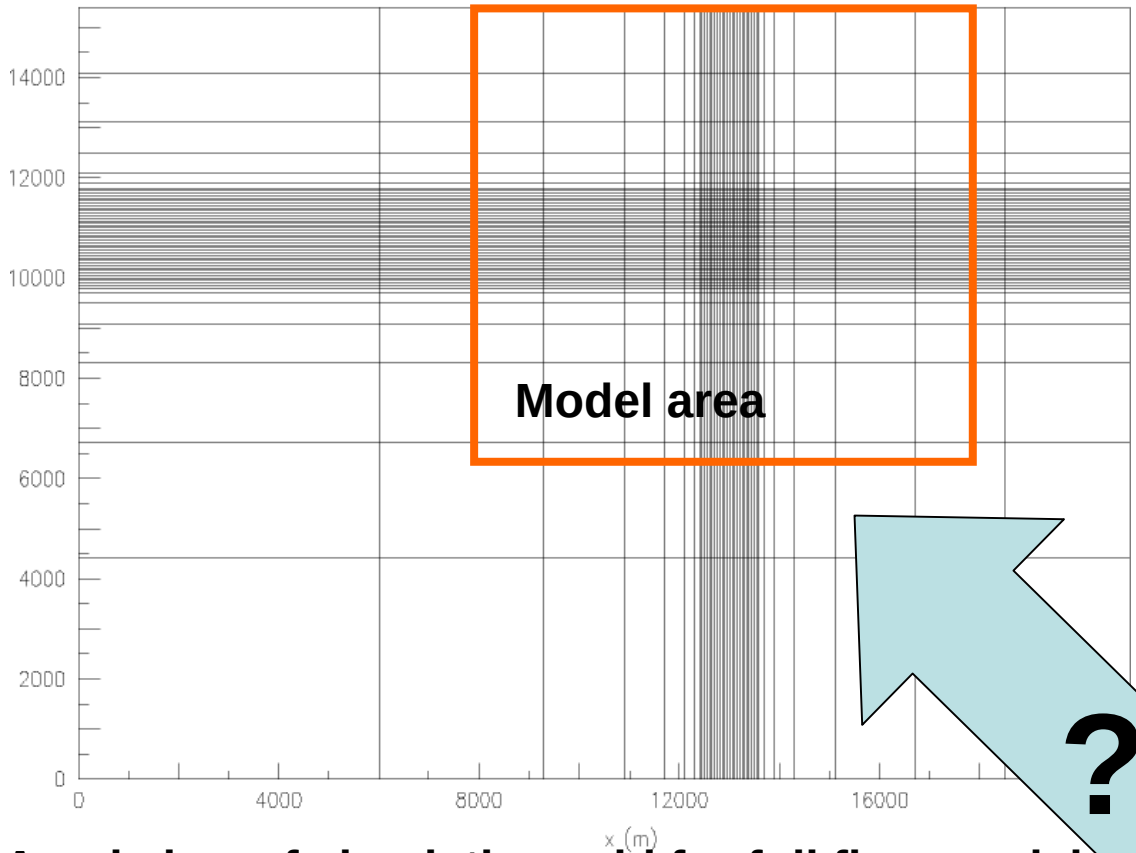
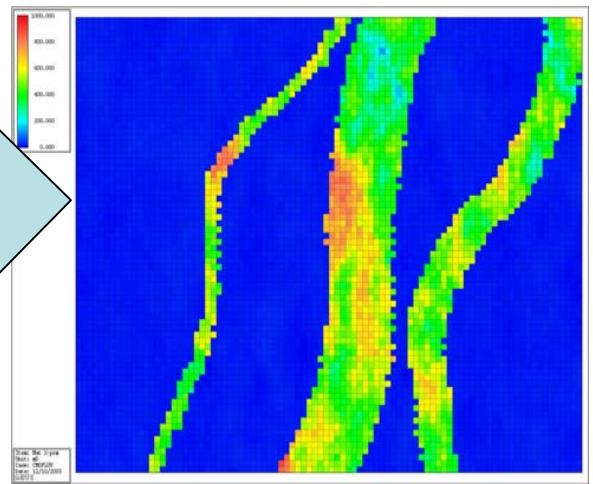
Permeability model must be merged into Eclipse model, most likely with coarser and non-uniform grid



nx = 38
ny = 53

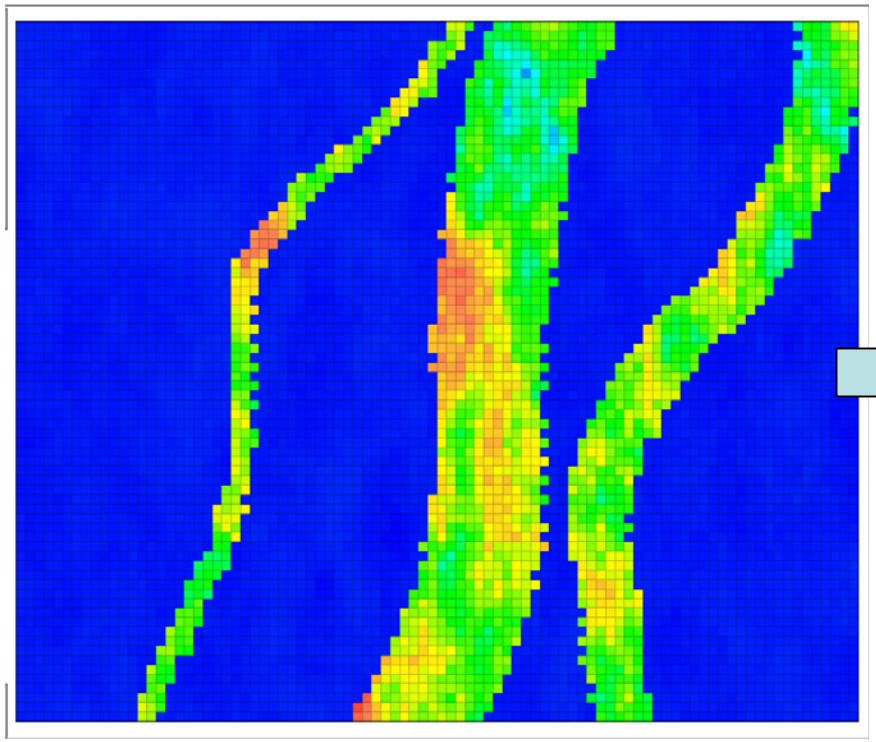
dx = 50 – 6000 m
dy = 50 – 4400 m

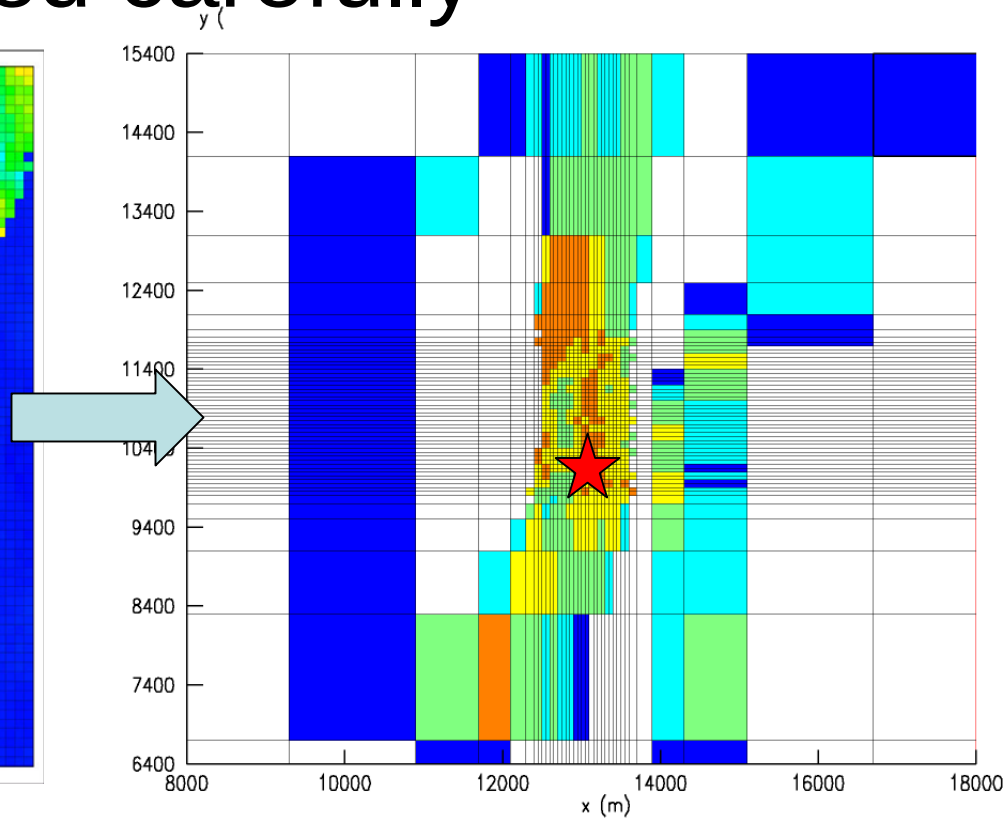
?



Areal view of simulation grid for full flow model

The upscaling step must be evaluated carefully





Kx in top layer of model

Upscaled into eclipse grid

Floodplain (blue and white colour) Kx-average = 20 mD

Channel sand avg. Kx = 500 mD

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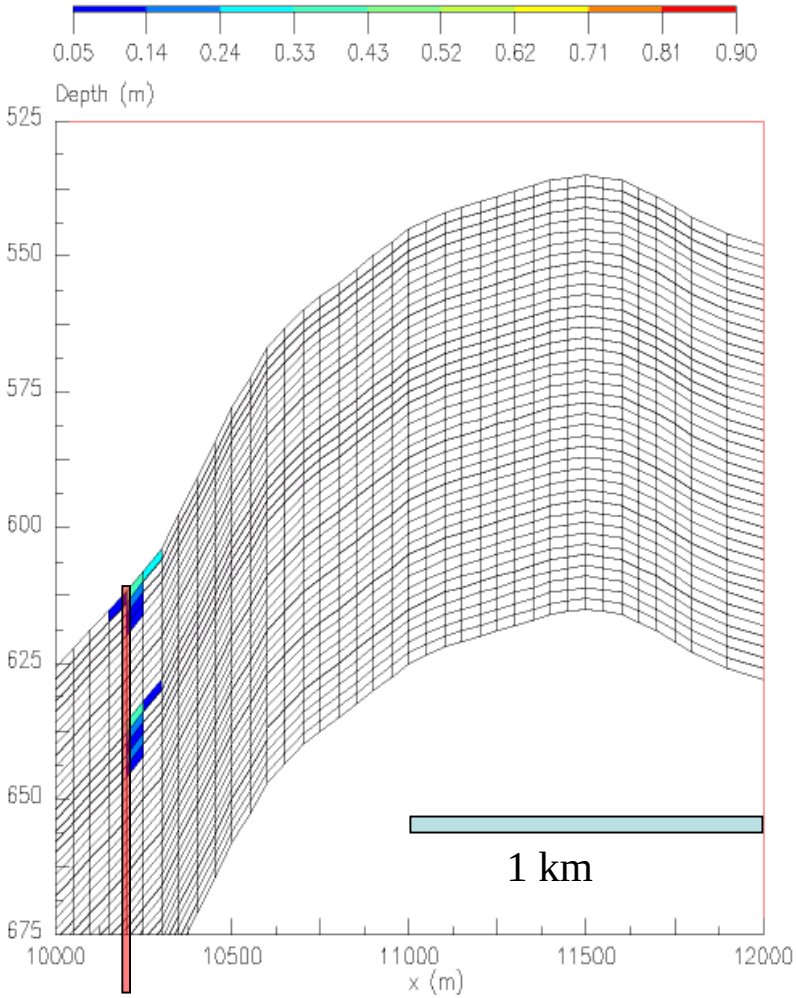
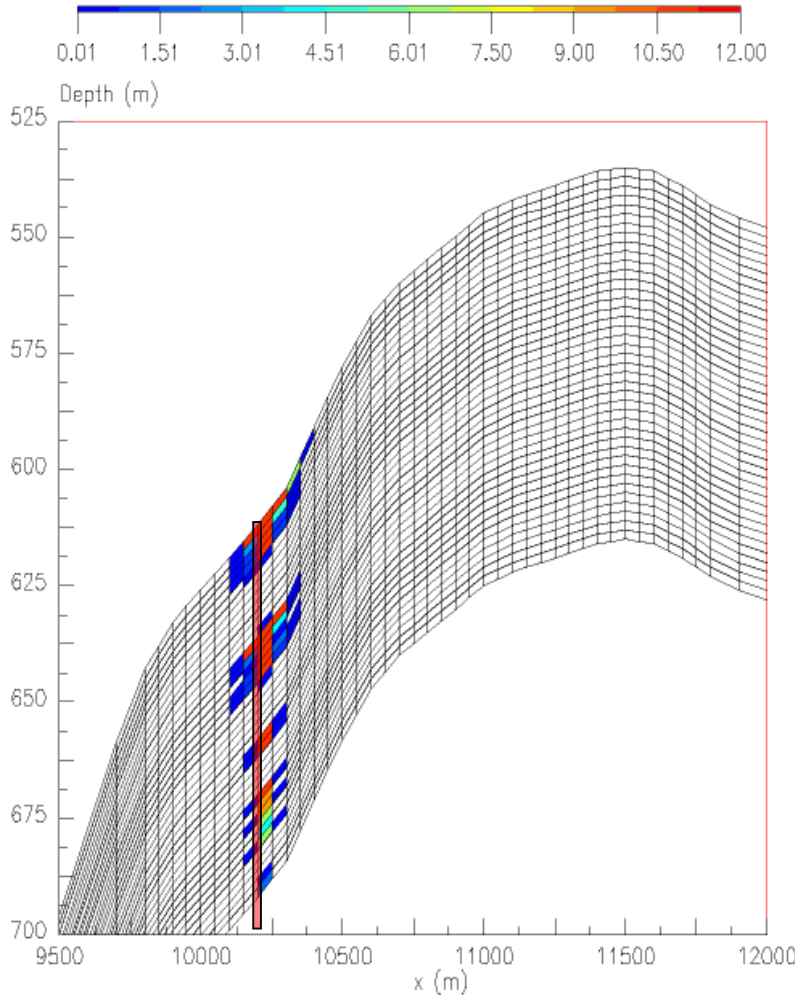


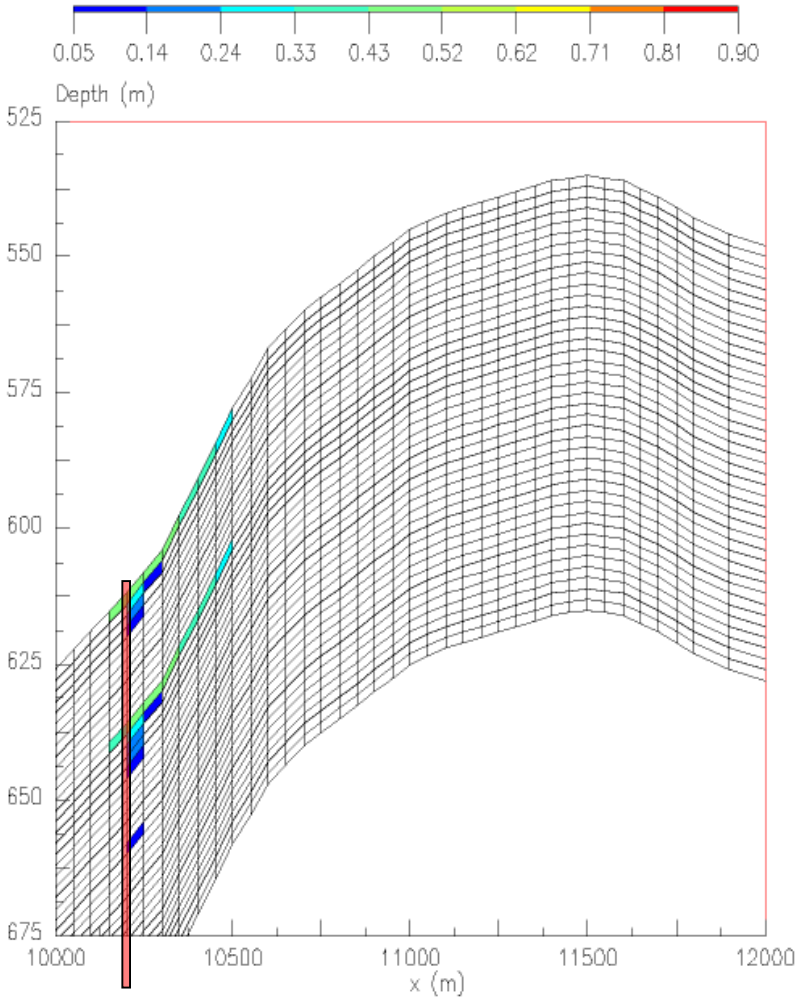


CO_2 saturation

after 1 month

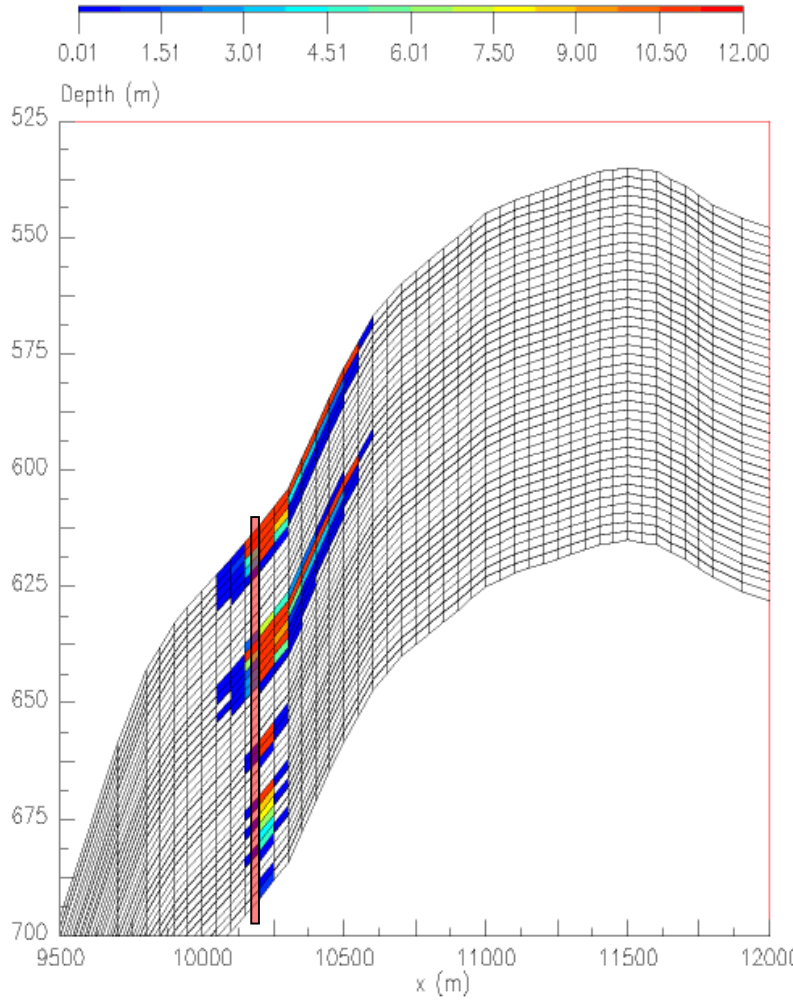
dissolved CO_2

N-S vertical section in 3D Eclipse simulation

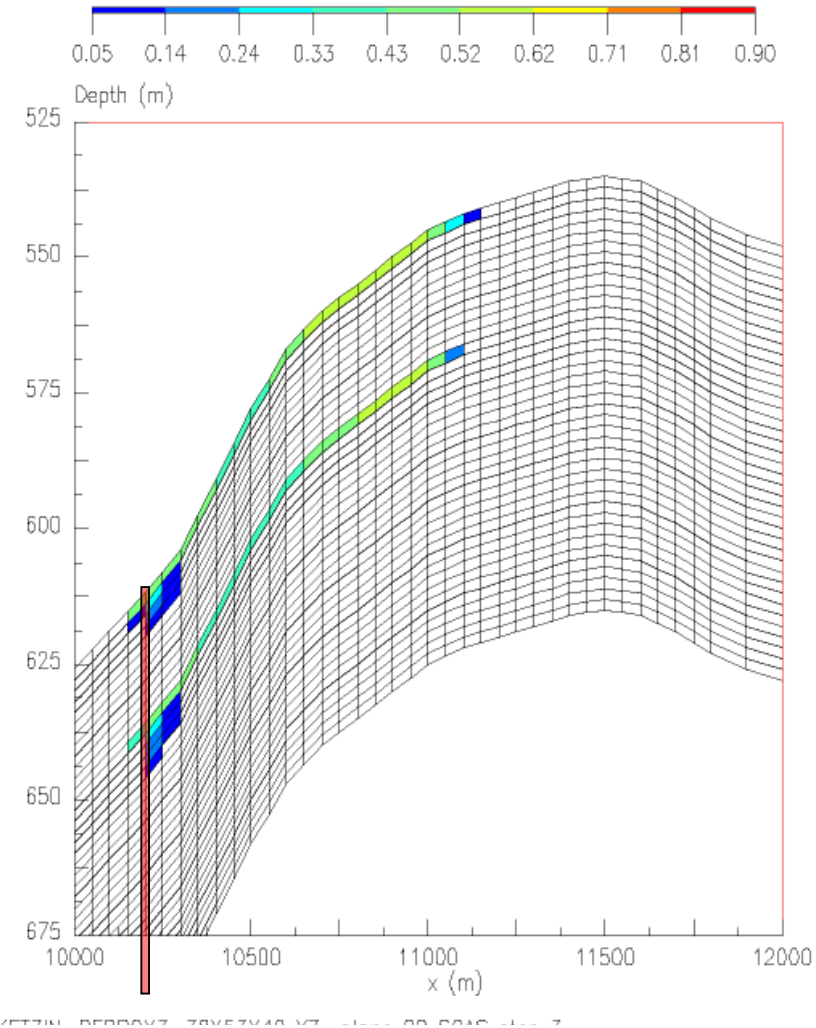


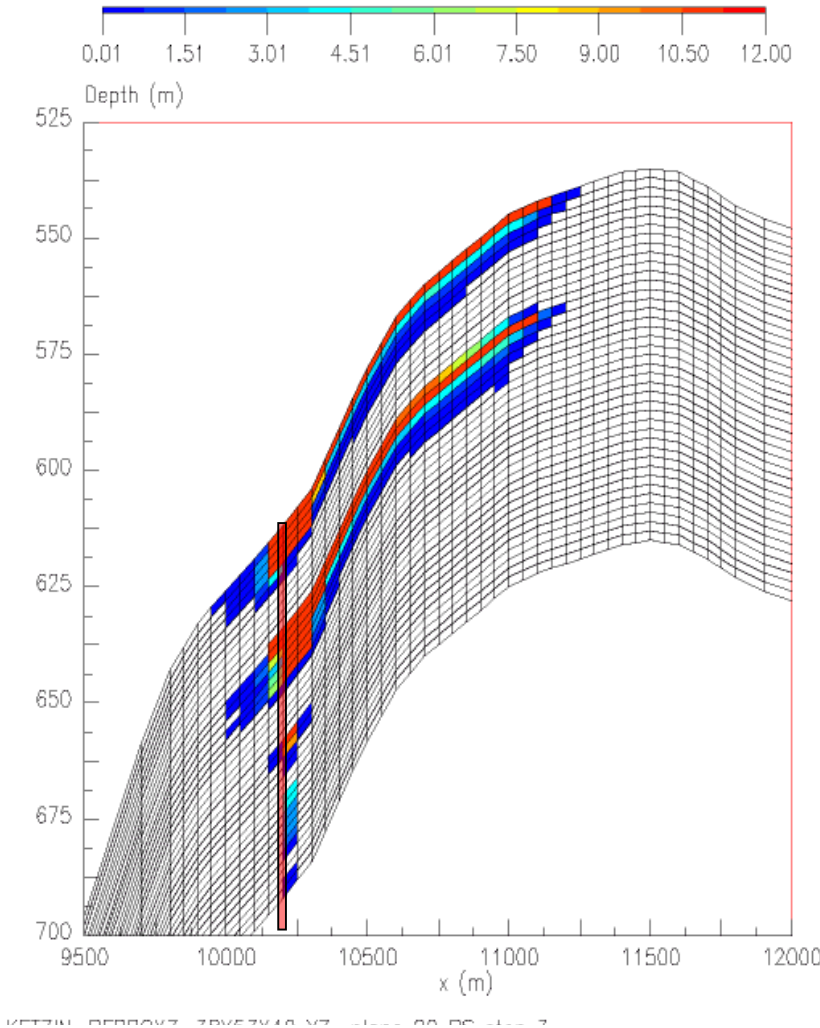
CO_2 saturation

after 6 months



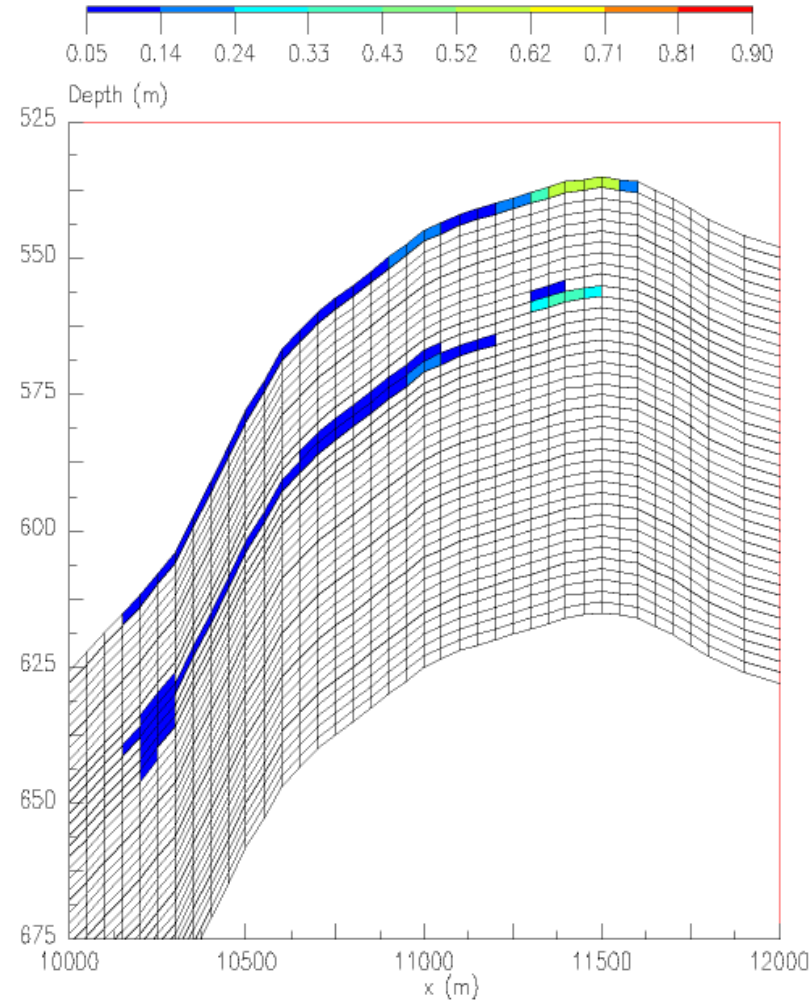
dissolved CO_2





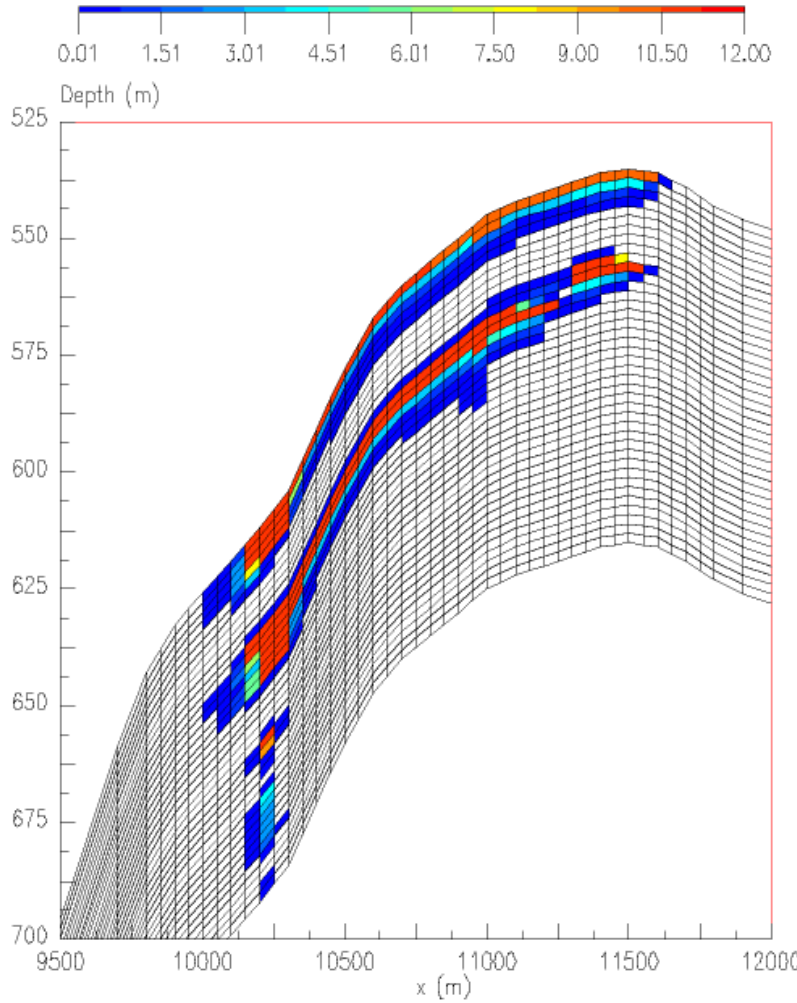
CO_2 saturation **dissolved CO_2**

after 2.5 years and injection is stopped

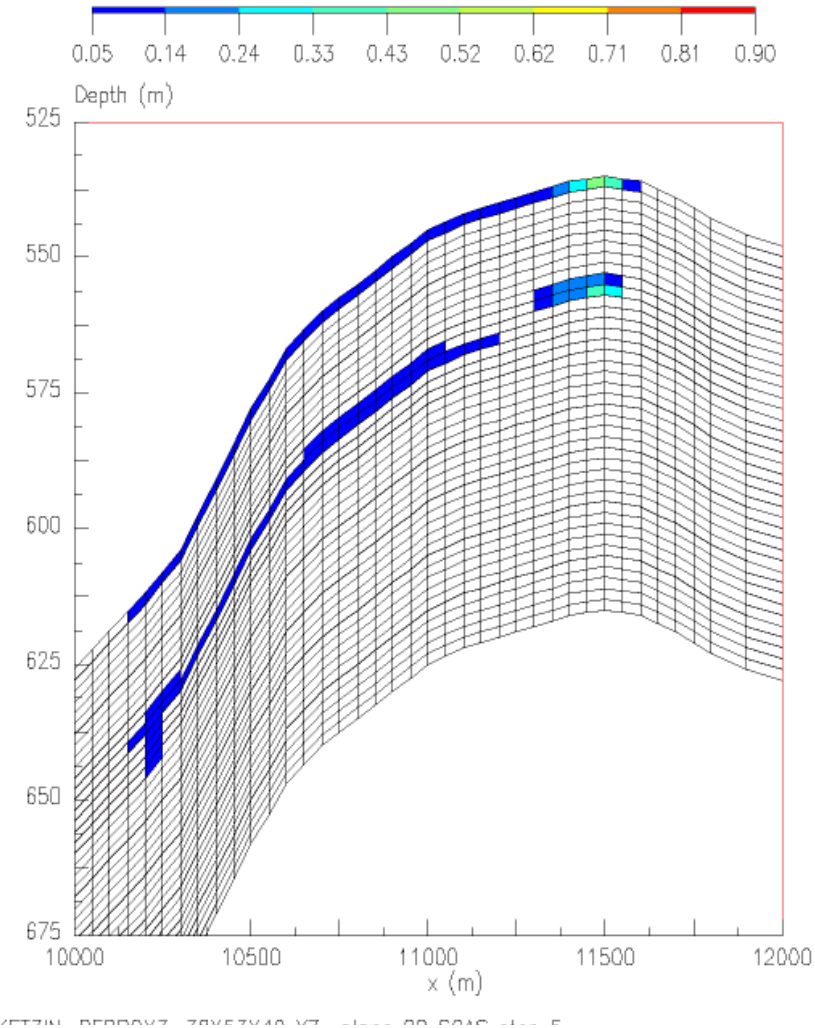


CO_2 saturation

after 10 years

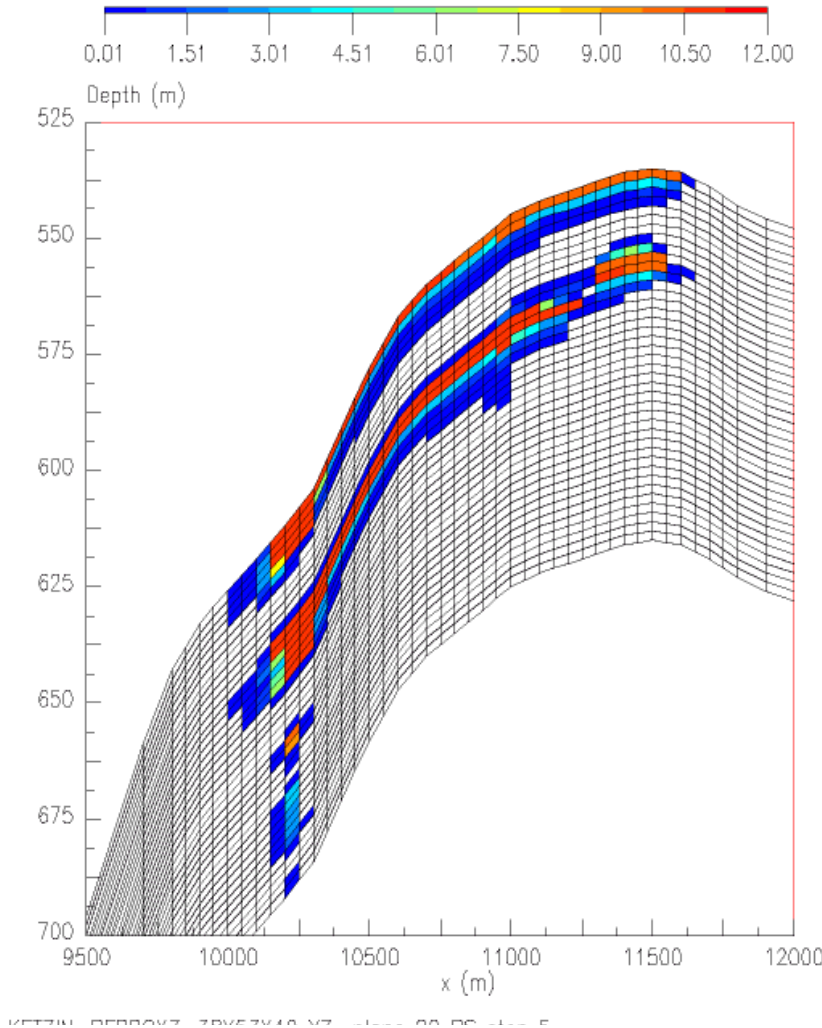


dissolved CO_2



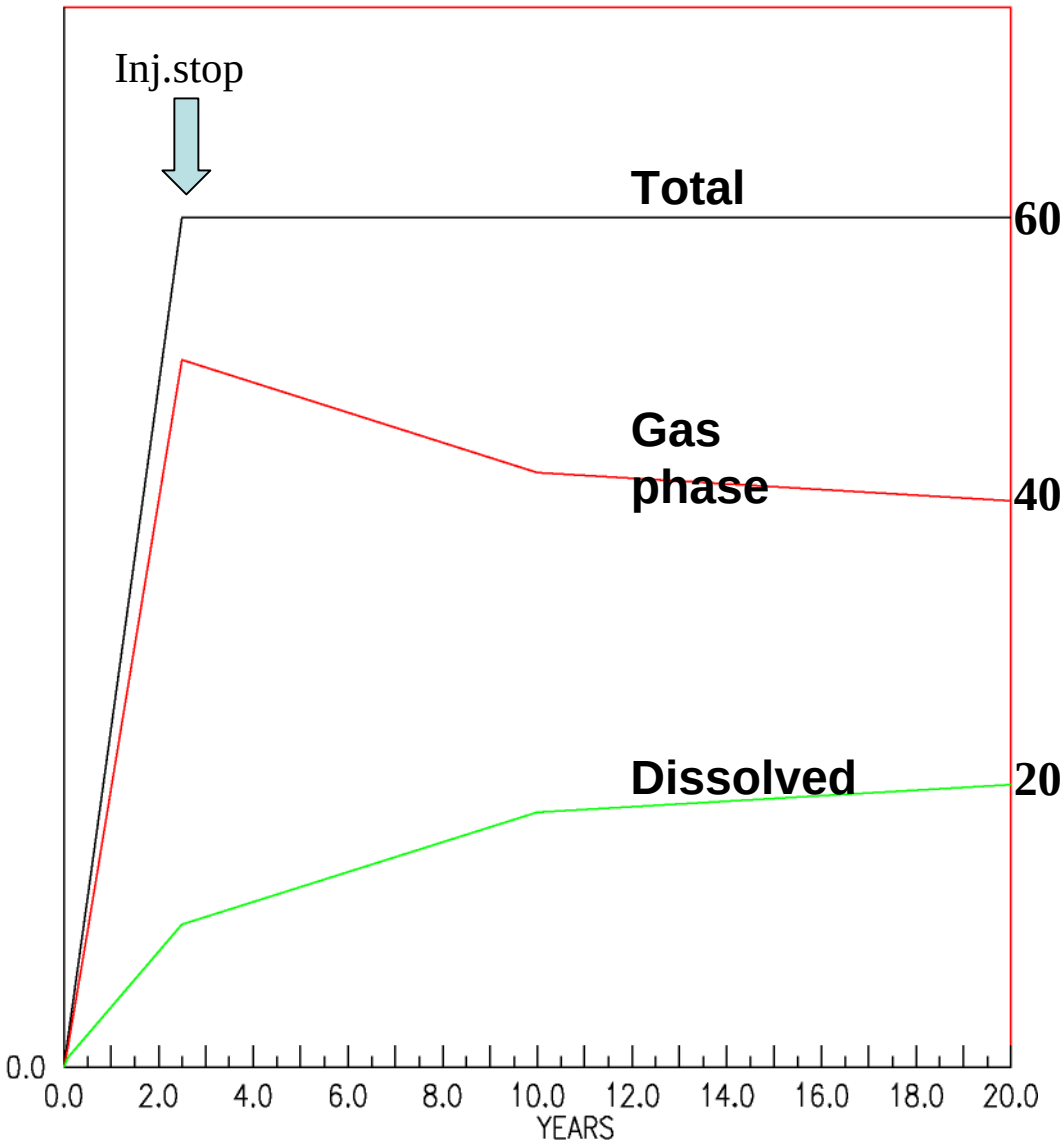
CO_2 saturation

after 20 years



dissolved CO_2

CO_2-in-place vs. time



At 20 years:

40 ktons CO_2 in gas phase

20 ktons CO_2 dissolved in brine

At 2.5 years:

50 ktons CO_2 in gas phase

10 ktons CO_2 dissolved in brine

Conclusions

- Site characterisation including modelling and upscaling into flow model must be:
  - updatable
  - repeatable
  - stochastic
  - realistic
  - auditable

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